MoBall: An Energy-Harvesting & Self-Propelling Spherical Sensor Platform

Completed Technology Project (2015 - 2018)

Project Introduction

There are many harsh, windy environments where a persistent in situ mobile sensor network could provide valuable data to help answer outstanding questions in the planetary sciences. On Earth, a network of distributed mobile sensors capable of energy-harvesting can provide the spatial resolutions and mission durations necessary to capture the seasonal environmental characteristics of the Arctic and Antarctic in a cost-effective manner. However, it is not possible to power these sensors using solar energy in the long dark polar winters. Mars, and Saturn's moon Titan, are also environments where a distributed mobile sensor network could enhance understanding of geology and climate. Similar to the Polar Regions, solar power cannot always be relied upon on Mars or Titan but surface winds are consistent. MoBall is a mobile sensor platform that harvests wind-energy and generates self-propulsion, and it is a candidate for deployment in the above environments. A unique electromechanical apparatus uses solenoids to harvest kinetic energy of permanent magnets as they slide freely within MoBall during wind-driven motion. The same apparatus generates self-propulsion by adjusting the magnet positions via powered solenoids, manipulating the position of the center of mass, and achieving motion from rest or biased steering. Each ball is outfitted with low-mass, low-power sensors and electronics for peer-to-peer and satellite data transmission. Teams of MoBalls will be deployed cooperatively with other in situ assets, forming a distributed sensing network over a large spatial domain. The innovative merging of energy-harvesting and mobility into a single sensor platform increases network flexibility, productivity, and lifespan. The objectives of this grant include (i) To validate self-propulsion from rest and biased steering through a series of prototypes and field tests, (ii) To employ optimal control techniques that intelligently toggle between energy-harvesting and control modes while executing basic maneuvers, and (iii) To outfit MoBall with scientifically-relevant sensors and assess the total energy budget, data transmission, science gathering capability, and environmental survivability. Achievement of the above objectives will likely entail academic contributions to switched hybrid optimal control theory and nonholonomic mechanics with Lagrangian symmetries. In addition, the development of MoBall's mechanical and electrical systems are novel engineering contributions that may be applicable to other robots and NASA assets.

Anticipated Benefits

There are many harsh, windy environments where a persistent in situ mobile sensor network could provide valuable data to help answer outstanding questions in the planetary sciences. The innovative merging of energy-harvesting and mobility into a single sensor platform increases network flexibility, productivity, and lifespan.

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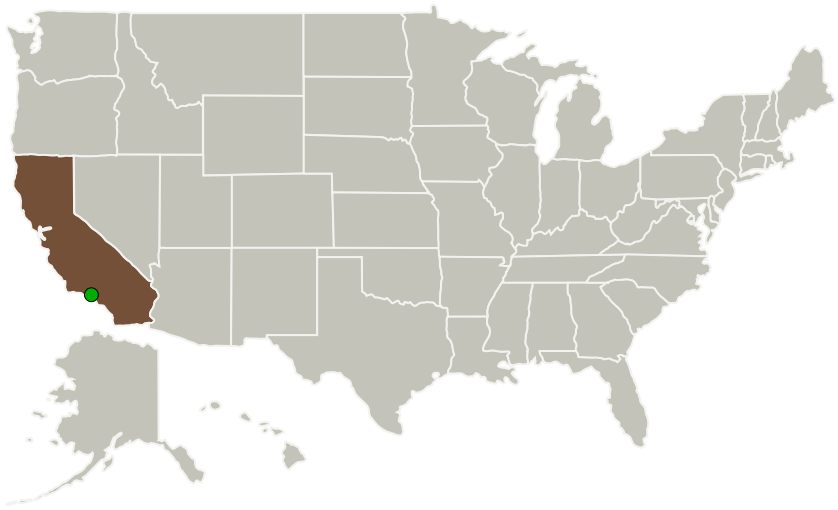
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Lead Organization	Academia	Pasadena, California
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

California Institute of Technology (CalTech)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Joel W Burdick

Co-Investigator:

Matthew Burkhardt

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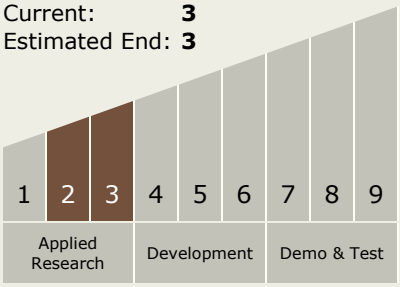
Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX04 Robotic Systems
  - TX04.2 Mobility
    - TX04.2.2 Above-Surface Mobility

Target Destinations

Earth, Others Inside the Solar System, Mars